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(54) Name of the invention:

Aerial Power Transmission Line

(21) Filed Number: Application Hei-Sei 1-237907

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(71) Patent Assignee: Furukawa Electric Co. LTD.

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[Note: Names, addresses, company names and brand names are translated in the most common manner. Japanese language does not have singular or plural words unless otherwise specified by a numeral prefix or a general form of plurality suffix.]

Description of the invention

1. **Name of the invention**

Aerial Power Transmission Line

2. **Scope of the Claims**

Aerial power transmission line characterized by the fact that it is a line where on the surface of a twisted wire formed from a metal element wire, an intermediate layer is formed that is comprised of at least one type of transition metal from the transition metals from the groups IV, V, and on the surface of that as the outermost layer, an electroconductive ceramics layer is formed that has as its main component at least one type of carbide, nitride, di-boride compound of the transition metals from groups IV, V.

3. **Detailed Explanation of the Invention**

[Technological Field of the Invention]

The present invention is an invention about an aerial power transmission line (including aerial ground lines) with excellent lightning resistant properties.

[Previous Technology and Its Problems]

Generally, as the aerial power transmission lines, single metal lines like bare copper, aluminum, steel etc., or twisted wires where these composite wires have been twisted, are used. In the case of these aerial power transmission line routes, the most frequently generated accidents are the lighting accidents, and it is very strongly desired to discover an aerial power transmission line capable of eliminating these accidents.

In the case of the aerial power transmission lines, through the heat that is generated by the lightning impact electrical flow when a falling lightning is encountered, melting losses, element wire melting separation, etc., are generated, and it has been difficult to prevent these. Taking this into consideration, previously, the aerial power transmission line has been suggested (Japanese Patent Application Hei-Sei 1-80476), where the surface of the twisted wire has been covered by a ceramics layer, which has a melting point that is higher than the melting point of iron, and also, which has electroconductive

properties. In the case of this aerial power transmission line the lightning resistance properties have been significantly improved and an excellent effect has been obtained. However, there has been the drawback that because of the difference in the thermal expansion between the twisted wire and the electroconductive ceramics layer, it has been easy to generate damage like a separation or peeling off of the ceramics layer, etc., and also, it has been easy to generate pin holes at the surface of the twisted wire through stains or defects.

[Problems Solved by the Present Invention]

The present invention is an invention that has been produced as a result from the studies of the above described problems, and it is an invention whereby an aerial power transmission line is invented that has excellent lightning resistance properties and also where the compatibility properties between the twisted wire and the electroconductive ceramics layer are high, and the thermal expansion difference is made to be small, and there are no separation or peeling off of the ceramics layer etc., damages, and also, the surface stains or defects are minimized and the generation of pin holes is suppressed.

[Measures in Order to Solve the Problems and Effect]

The present invention is an aerial power transmission line characterized by the fact that it is a line where on the surface of a twisted wire formed from a metal element wire, an intermediate layer is formed that is comprised of at least one type of transition metal from the transition metals from the groups IV, V, and on the surface of that as the outermost layer, an electroconductive ceramics layer is formed that has as its main component at least one type of carbide, nitride, di-boride compound of the transition metals from groups IV, V.

And namely, in the case of the present invention as an intermediate layer between the twisted wire and the outermost, electroconductive ceramics layer, a layer is used that is formed from the same transition metals as the transition metals used in the carbides, nitrides and di-borides of the transition metals from groups IV and V, which are used as the outermost layer.

The carbides, nitrides, di-borides etc., of the transition metals from groups IV, V, for example, Ti, Zr, Hf, V, Nb, Ta, have strong anti-oxidation properties and anti-sulfidization properties, and their hardness and melting points are high, and their wear is low, and they show good properties, and together with that they are also materials that have good electroconductive properties. Because of that, if the aerial power transmission lines are covered by these materials, the lightning resistance properties of the aerial power transmission line is increased over the lightning resistance properties of the aerial power transmission lines according to the previous technology. Also, the lightning electrical flow time period is on the order of micro seconds, and it is short, and because of that there is little amount of heat transfer from the cover layer to the inner part conductive metal, and it is possible to eliminate the melting loss of the inner part conductive metal material. Then, in the case of aerial ground line, in order to utilize the

lightning hindrance effect, it is necessary that this outer layer be an electroconductive layer, and it is desirable that its bulk electrical resistance coefficient be at or lower than 100 μΩ - cm.

However, in such a state as is, because of the thermal expansion difference existing between the twisted wire and the electroconductive ceramics layer, there is a generation of separation and peeling off of the ceramics layer.

Then, if the electroconductive ceramics layer is directly coated on the twisted wire, there is also the drawback that a misfit of the lattice constant is generated and the crystallization control properties are poor.

Then, according to the present invention, on the surface of the twisted wire, as an intermediate layer, a layer from the same transition metals as those used in the electroconductive ceramics layer, is formed, and by that it is a material where the compatibility properties between the twisted wire and the electroconductive ceramics layer, are high, the thermal expansion difference is made small and together with that the lattice constant misfit is made small.

By doing that, at the interface between the twisted wire and the intermediate layer, the same kind of metals are in contact, and there are the same metals between the intermediate layer and the electroconductive ceramics, and because of that the affinity properties are good and the adhesive properties are improved and together with that the stress due to the thermal expansion difference is relaxed, and the electroconductive ceramics layer damage is eliminated. Then, through the twisted layer/intermediate layer/electroconductive ceramics layer layer lamination, the generation of pin holes is prevented. Then, the lattice constants of the transition metal in the intermediate layer and of the transition metal carbides, nitrides, di-borides in the electroconductive ceramics layer, have close values, and because of that the misfit is made to be small, and it becomes possible to have good crystallization control.

However, in the case of the intermediate layer according to the present invention, it has at least one type of Ti, Zr, Hf, V, Nb, Ta, etc., transition metals from groups IV or V, and also, as the outermost layer, conductive ceramics layer, a material is used that has as its main component at least one type from any of the group IV or V transition metals Ti, Zr, Hf, V, Nb, Ta carbides, nitrides, di-borides.

Then, as the metal element wire, copper wire, aluminum wire, steel wire etc., ground aerial power transmission line element wires, can be used.

[Practical Examples]

Here below, an explanation will be provided regarding one practical implementation example of the present invention.

As it is shown according to Figure 1, on a wire obtained as 7 metal element wires (1) with a diameter of 3.2 mm, have been twisted, the transition metal intermediate layer (2) has been covered and after that electroconductive ceramics layer (30 formed from group IV, V transition metal carbides, nitrides or di-borides, has been covered, and this is explained in the described example.

Practical Example 1

On a twisted wire obtained by twisting 7 aluminum element wires, by using vacuum vapor deposition, a Zr intermediate layer was coated at a thickness of 20 microns, and after that, ZrB2 layer with a thickness of 70 microns was formed, and an aerial power transmission line, was manufactured.

Practical Example 2

On a twisted wire obtained by twisting 7 copper element wires, by using vacuum vapor deposition, a Zr intermediate layer was coated at a thickness of 20 microns, and after that, ZrN layer with a thickness of 50 microns was formed, and an aerial power transmission line, was manufactured.

Practical Example 3

On a twisted wire obtained by twisting 7 hard steel element wires, by using sputtering, a Ti intermediate layer was coated at a thickness of 10 microns, and after that, by using reduced pressure plasma, a TiB2 layer with a thickness of 100 microns was formed, and an aerial power transmission line, was manufactured.

Reference Example 1

On a twisted wire obtained by twisting 7 hard steel element wires, by using plasma melting and injection, a TiB2 layer with a thickness of 100 microns was formed, and an aerial power transmission line, was manufactured.

Reference Example 2

7 hard steel element wires were twisted and an aerial power transmission line, was manufactured.

The heat cycle testing, the anti-oxidation properties, and the sulfidization resistance properties of the manufactured by the above aerial power transmission lines, were studied. The results from these studies are shown according to the presented in Table 1.

Table 1:

	Heat Cycle Test	Anti-Oxidation Properties	Sulfidization Resistance Properties
Practical Example 1	O	O	O
Practical Example 2	O	O	O
Practical Example 3	O	O	O
Reference Example 1	Δ	O	O
Reference Example 2	-	X	X

Remark) O .....good; Δ.....somewhat good, X.....poor; -.....no

Moreover, regarding the heat cycle testing, 100 cycles were conducted where the aerial power transmission line was heated from room temperature to 400oC, and then the apparent separation of the electroconductive ceramics was observed.

Regarding the anti-oxidation (oxidation resistance) properties, the aerial power transmission line was placed for a period of 500 hours in an ambient atmosphere at a temperature of 400oC and the degree of the oxidation was observed through the state of its surface. Also, regarding the sulfidization resistance properties, the aerial power transmission line was placed for a period of 1000 hours in an ambient atmosphere of 10 ppm of hydrogen sulfide and at a relative humidity of 90 %, and then its surface state was observed.

As it can be seen from Table 1, the aerial power transmission line according to the present invention has good oxidation resistance properties and sulfidization resistance properties and from the heat cycle testing it is understood that there is no damage of the electroconductive ceramics layer due to the thermal expansion difference.

[Results]

As it is clear from the above described, according to the present invention an aerial power transmission line is obtained that has lightning resistance properties, and also, where the adhesive properties are improved and together with that the stress due to the thermal expansion is relaxed, and the electroconductive ceramics layer damage is prevented, and then, the generation of pin holes has also been prevented, and because of that the present invention has a significant technological effect.

4. Brief Explanation of the Figure

Figure 1 is a cross sectional view diagram of the aerial power transmission line pertaining to one practical example of the present invention.

1.....metal twisted wire, 2.....intermediate layer,
3.....electroconductive ceramics layer.

Patent Assignee: Furukawa Electric Co. Ltd.

Translated by Albena Blagev ((651) 735-1461 (h), (651) 704-7946 (w))

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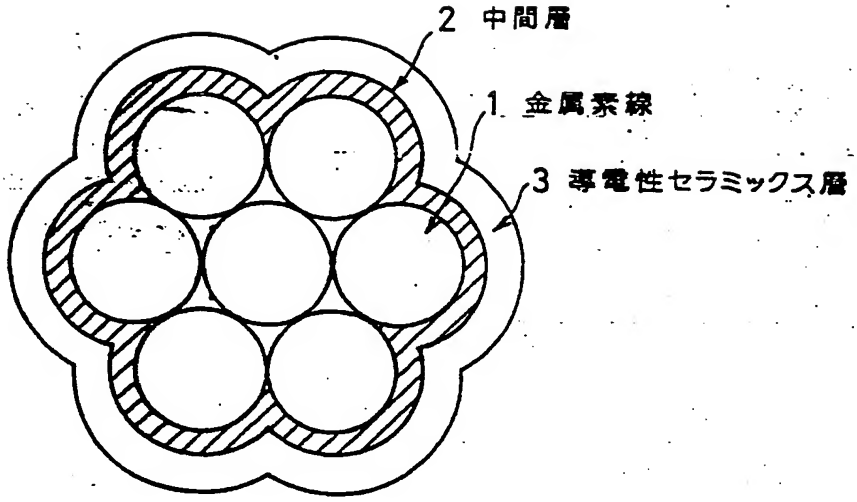

第 1 図

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審査請求　未請求　請求項の数 1　(全3頁)

⑤発明の名称　架空送電線

⑳特　願　平1-237907
㉒出　願　平1(1989)9月13日

⑦発明者　尾崎　正則　東京都千代田区丸の内2丁目6番1号　古河電気工業株式会社内
⑦出願人　古河電気工業株式会社　東京都千代田区丸の内2丁目6番1号

明　細　書

1．発明の名称　架空送電線

2．特許請求の範囲

金属素線からなる鉄線の表面に遷移金属Ⅳ、Ⅴ族の内少なくとも1組の遷移金属からなる中間層を形成し、その表面に最外層として遷移金属Ⅳ、Ⅴ族の炭化物、窒化物、ニホウ化物の内少なくとも1組を主成分とする導電性セラミックス層を形成したことを特徴とする架空送電線。

3．発明の詳細な説明

〔産業上の利用分野〕

本発明は、耐雷性に優れた架空送電線（架空地線を含む）に関する。

〔従来の技術とその課題〕

一般に架空送電線は、銅の鋼、アルミニウム、鋼などの単金属線、またはこれらの複合線を組合せた鉄線が使用されている。この架空送電線路において発生する事故として最も多いのは雷害事故であり、この事故の防止可能な架空送電線の出現が強く要望されている。

架空送電線は、落雷に遭遇すると雷撃電流による発熱で、鉄線に溶損、素線溶断などが発生し、これを防止することは困難であった。これに鑑み、先に鉄線の表面を融点が鉄の融点よりも高く、かつ導電性を有するセラミックス層により被覆した架空送電線を提案した（特願平1-80476号）。この架空送電線は耐雷性が著しく向上する優れた効果を示した。しかしながら鉄線と導電性セラミックス間において熱膨張の差によりセラミックス層に割れや剥離等の損傷が生じ易く、また鉄線表面の汚染や欠陥によりピンホールが発生し易い欠点があった。

〔発明が解決しようとする課題〕

本発明は上記の問題について検討の結果なされたもので、耐雷性に優れ、かつ鉄線と導電性セラミックス層との親和性を高め、熱膨張の差を少なくして、セラミックス層の割れや剥離などの損傷がなく、また表面汚染や欠陥を減少してピンホールの発生を抑制した架空送電線を開発したものである。

〔課題を解決するための手段および作用〕

本発明は、金属素線からなる燃線の表面に遷移金属Ⅳ、Ⅴ族の内少なくとも１種の遷移金属からなる中間層を形成し、その表面に最外層として遷移金属Ⅳ、Ⅴ族の炭化物、窒化物、ニホウ化物の内少なくとも１種を主成分とする導電性セラミックスを形成したことを特徴とする架空送電線である。

すなわち本発明は、燃線と最外層の導電性セラミックスとの中間層として、最外層に用いる遷移金属Ⅳ、Ⅴ族の炭化物、窒化物、ニホウ化物の内遷移金属と同じ遷移金属を形成させるものである。

遷移金属Ⅳ、Ⅴ族、例えばＴｉ、Ｚｒ、Ｈｆ、Ｖ、Ｎｂ、Ｔａの炭化物、窒化物、ニホウ化物などは、耐酸化性、耐硫化性に強く、硬度及び融点が高く、摩耗が少なく、良好な性質を示すと共に、良好な導電性を有するものである。このため、この材料で架空送電線を被覆すると、架空送電線の耐雷性は従来の架空送電線よりも向上する。また雷電流の流れる時間はμsec のオーダーで短いので被覆層から内部導体金属への熱伝達量は少なく、内部導体金属の溶損を防ぐことができる。さらに架空地線は避雷作用を果すために、その外層は導電性であることが必要であり、その体積電気抵抗率は 100μΩ－cm以下であることが望ましい。

ところで、このままでは燃線と導電性セラミックス層の間において、熱膨張率の差によりセラミックス層に割れや剥離が生じる。

さらに燃線上に導電性セラミックス層を直接コーティングすると格子定数のミスフィットが生じ結晶制御性が悪い欠点もある。

そこで本発明においては、燃線上に形成する導電性セラミックス層と同じ遷移金属を中間層として形成し、燃線と導電性セラミックス層間の親和性を高め、熱膨張率の差を小さくすると共に格子定数のミスフィットを小さくしたものである。

このようにすることにより燃線と中間層との界面は金属同志が接し、中間層と導電性セラミックス層間は同種金属であるため親和性が良く密着性を向上すると共に熱膨張差による応力を緩和し、

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導電性セラミックス層の損傷を防止する。そして燃線／中間層／導電性セラミックス層という積層化によりピンホールの発生を防止する。さらに中間層の遷移金属と導電性セラミックス層の遷移金属の炭化物、窒化物、ニホウ化物との格子定数は近い値を有するためミスフィットが小さく良好な結晶制御が可能となる。

しかして本発明において中間層は遷移金属Ⅳ、Ⅴ族のＴｉ、Ｚｒ、Ｈｆ、Ｖ、Ｎｂ、Ｔａなどの少なくとも１種であり、また最外層の導電性セラミックス層としては遷移金属Ⅳ、Ⅴ族のＴｉ、Ｚｒ、Ｈｆ、Ｖ、Ｎｂ、Ｔａの炭化物、窒化物、ニホウ化物の内何れか１種を主成分とするものが用いられる。

さらに金属素線としては銅線、アルミニウム線、鋼線などの他架空送電線の素線として用いられるものが適用できる。

〔実施例〕

以下に本発明の一実施例について説明する。

第１図に示すように直径 3.2㎜φの金属素線(1)を７本燃合せた線に遷移金属の中間層(2)を被覆した後、遷移金属Ⅳ、Ⅴ族の窒化物、炭化物、ニホウ化物の導電性セラミックス層(3)を被覆した例について述べる。

実施例１

アルミニウム素線を７本燃合せた燃線に真空蒸着によりＺｒの中間層を20㎛の厚さにコーティングし、続いてＺｒＢ₂層を70㎛の厚さに形成して架空送電線を作製した。

実施例２

銅素線を７本燃合せた燃線に真空蒸着によりＺｒの中間層20㎛の厚さにコーティングし、続いて反応性蒸着によりＺｒＮ層を50㎛の厚さに形成して架空送電線を作製した。

実施例３

硬鋼素線を７本燃合せた燃線にスパッタリングによりＴｉの中間層を10㎛の厚さにコーティングし、続いて減圧プラズマ溶射によりＴｉＢ₂層を100 ㎛の厚さに形成して架空送電線を作製した。

比較例１

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硬鋼素線を７本撚合せた撚線にプラズマ溶射によりＴｉＢ₂層を100 μmの厚さに形成して架空送電線を作製した。

比較例２

硬銅線を７本撚合せた架空送電線を作製した。

このようにして作製した上記架空送電線について、ヒートサイクル試験、耐酸化性、耐硫化性について調べた。その結果を第１表に示す。

第　１　表

	ヒートサイクル試験	耐酸化性	耐硫化性
実施例１	○	○	○
〃　２	○	○	○
〃　３	○	○	○
比較例１	△	○	○
〃　２	—	×	×

註）○…良　△…稍良　×…不良　—…なし

なおヒートサイクル試験は、架空送電線を室温から 400℃に加熱することを 100サイクル行なって導電性セラミックス層の外観剥れを観察した。耐酸化性は架空送電線を400 ℃の大気中に 500時間放置して、その表面状況により酸化の程度を観察した。また耐硫化性は架空送電線を相対湿度90％、硫化水素10ppm の大気中に1000時間放置してその表面状況を観察した。

第１表から明らかなように、本発明の架空送電線は耐酸化性及び耐硫化性が良好でヒートサイクル試験において熱膨張差による導電性セラミックス層の損傷のないことが判る。

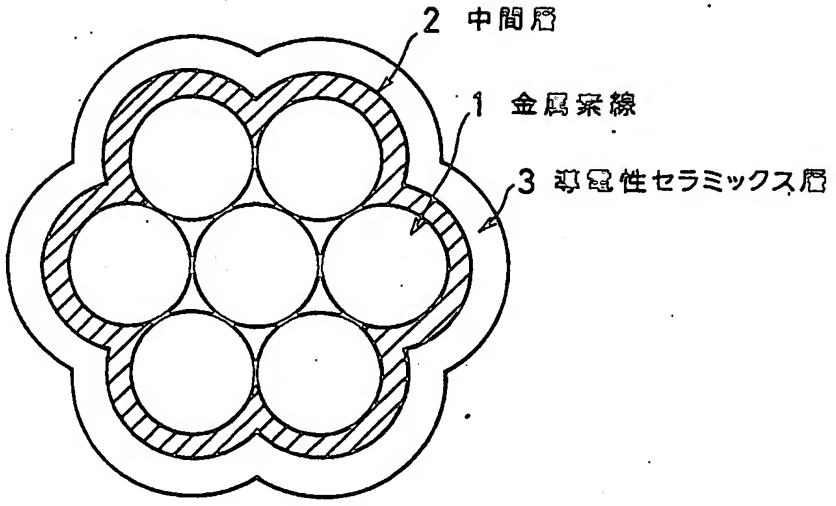
（効果）

以上に説明したように本発明によれば、耐蝕性を有し、かつ密着性が向上すると共に熱膨張による応力を緩和し、導電性セラミックス層の損傷を防止し、さらにピンホールの発生を防止した架空送電線が得られるもので工業上顕著な効果を奏するものである。

４．図面の簡単な説明

第１図は本発明の一実施例に係る架空送電線の横断面図である。

１…金属素線、　２…中間層、　３…導電性セラミックス層。



第　１　図